Environmental effects in the third moment of voltage fluctuations in a tunnel junction.

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This is the first successful measurement of electrical current fluctuations beyond the second moment. The history of the second moment goes back to 1916, when Walter Schottky identified the discreteness of the electrical charge as a source of noise in vacuum tubes. This so-called "shot noise" is mixed with thermal noise, and one needs voltages large compared to temperature in order to extract the non-equilibrium shot noise from the background of thermal noise. Shot noise measurements are notoriously difficult because of this requirement to keep the sample cold in the presence of a large current.

Leonid Levitov and Misha Reznikov noticed two years ago that the third moment of the current fluctuations in a tunnel junction should not suffer from the contamination by thermal fluctuations, basically because of the different parity.. They proposed to use the third moment for measuring quasiparticle charge at high temperatures. The third moment should increase linearly with the applied voltage, with a slope set by the quasiparticle charge --- regardless of the value of the temperature.

The experiment is hard because the signal is so small. The central limit theorem ensures that moments higher than the second are suppressed. The first data (on an Al tunnel junction) was reported by Bertrand Reulet at a workshop in Dresden last December. It came as a surprise that the third moment is not at all a linear function of the applied voltage. In some samples it even changes sign as the voltage becomes larger than temperature.

A possible resolution of the anomaly is the interactions between the tunneling electrons and their electromagnetic environment. These interactions also affect the second moment, but there they can be accounted for by a simple linear rescaling. The effect on the third moment is nonlinear.

By incorporating the nonlinear feedback from the electromagnetic environment into their analysis, the Yale group has achieved a complete quantitative description of the voltage dependence of the third moment.

What is next? It is tempting to draw analogies with quantum optics, where higher order moments of photon noise are used routinely to identify complex states (entangled states, squeezed states, coherent states, etc.) of the electromagnetic field. Several proposals exist to detect quantum entanglement in condensed matter by correlating higher order current fluctuations. The ultimate goal is to develop "electron counting statistics" into a tool that is a useful as photon counting statistics. The Yale experiment has set the first step in this direction.